

DRAWINGS ATTACHED.



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COMPLETE SPECIFICATION.

Vibratory Tooth Brushes.

I, ANTOINE FRANCOIS REGIS PEYRON, a French Citizen, of 4 Rue de Londres, Paris 9e, France, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in vibratory toothbrushes.

Electric devices for brushing and cleaning teeth are already known. Their purpose is to generate a vibratory motion of the brush or any other instrument. It appears that the most serious practical difficulty so far encountered is due to the fact that the devices must be used in more or less close contact with liquids or wet areas. The danger of electrocution is all the more serious since the instrument is in contact with the mucous membrane in the mouth.

The main problem is to ensure complete watertightness of the housing (which contains the electrical vibrator) at the point of origin of the movements. The different devices tried up to now, could not stand up to wear, and eventually let some water into the housing. A short circuit or even the electrocution of the operator could result.

It is the principal object of the present invention to overcome the above-mentioned shortcomings.

In accordance with the present invention there is provided a vibratory device for cleaning teeth and gums having a brush-like treating element with a large number of soft, flexible filaments as bristles, a closed housing to which the treating element is attached, and a vibration generator so mounted within the housing that its vibrations are transmitted to the housing and hence to the treating element to cause the bristles to describe closed non-concentric curves in a plane transverse to their length.

While the invention is not limited to the use of an electrical vibration generator it will be realised that when such a generator is used it may be enclosed in a watertight manner within the housing and driven by a battery enclosed within the housing or supplied with current by a cable entering the housing through a watertight joint.

By way of example a number of embodiments of the invention will now be described with reference to the accompanying drawings, in which:—

Fig. 1 is a part-sectional view of a vibratory tooth-brush in accordance with the invention;

Fig. 2 is a diagrammatic illustration of a toothbrush in accordance with the invention having a non-vibrating handle;

Fig. 3 is a graph showing the theoretical amplitude of vibration of a brush bristle or filament;

Fig. 4 is a graph of the amplitude of vibration obtained in practice;

Fig. 5 is a diagram illustrating the operation of a normal toothbrush;

Fig. 6 shows the attachment of a bristle support to a handle or supporting arm;

Fig. 7 shows the construction of a curved treating element;

Figs. 8(a) and (b), 9(a) and (b), and 10(a) and (b) are respectively side and plan views of various forms of electromagnetic vibrator which may be used in devices in accordance with the invention;

Figs. 11(a) and 11(b) are, respectively, a plan view and a section on the line *b—b* of Fig. 11(a) of a further form of electromagnetic vibrator;

Fig. 12 shows a device in accordance with the invention driven by an air turbine;

Figs. 13(a) and 13 (b) are respectively a bottom plan view and a side view with the housing broken away of a device having a

bevel-gear drive from an electric motor.

Figs. 14 and 15 are diagrams for comparing the action of conventional toothbrushes with that of devices in accordance with the invention;

Figs. 16 and 17 are part-sectional views of two further embodiments of the invention;

Figs. 18(a) and (b), 19(a) and (b), 20(a) and (b), 21(a) and (b) and 22(a) and (b) are side and end views of various forms of treating element which may be used; and

Figs. 23 and 24 are respectively a longitudinal section and a transverse section on the line X—X of Fig. 23 of a further embodiment of the invention.

The toothbrush shown in Fig. 1 has a brush 2 mounted on one end of a closed housing 7 containing a motor 3 which drives a weight 1 eccentrically mounted on the shaft 4 of the motor 3. The motor 3 is fed by a battery 5 also contained within the housing 7 through a switch 6 which is operated through a flexible plate 8 of metal or plastic sealed in an aperture in the housing to ensure water-tightness. The eccentrically mounted weight 1 moves in a plane parallel to the support of the brush 2. The rotation of the weight 1 generates vibrations of the housing 7 and these are transmitted to the brush 2.

The motion of the brush is roughly elliptic and in the absence of damping or elasticity due to the manner in which the housing is supported would be exactly elliptic if the plane of rotation of the feeding head were the main plane of inertia. With an elastic suspension the movement may be in a figure of eight under certain conditions.

When the vibrating housing is held directly in the hand of the user the effective vibrating mass is increased by part of the weight of the hand in proportion to the firmness of grip of the user. This does not alter the nature or frequency of the vibrations of the brush but varies their amplitude.

As shown in Fig. 2 the closed water-tight housing 7 carrying the brush 2 may be mounted inside a fixed non-vibrating handle 9 by means of a mounting ring 10. This prevents damping of the vibrations by the hand. The elasticity of the mounting ring 10, which may be of rubber, influences the motion of the brush, as mentioned above.

The transverse elasticity of the mounting can be calculated in terms of the longitudinal elasticity. If d is the distance from the centre of gravity G of the housing 7 to the ring 10 and e is the average diameter of the ring, then:—

For a longitudinal shift Δx of the centre of gravity, the force is $F = K \cdot \Delta x \cdot \pi \cdot e$ (where K is the transverse modulus of elasticity of the ring).

For a transverse shift Δy of this centre of gravity, the moment is:—

$$F \cdot d = K \cdot \Delta y \cdot \frac{e}{2d} \cdot \frac{e^2}{2} = K \cdot \Delta y \cdot \frac{e^3}{4d}$$

$$\text{or } F = K \cdot \Delta y \cdot \frac{e^2}{4d^2}$$

The ratio of the two elasticities is:—

$$\frac{F / \Delta x}{F / \Delta y} = 4 \pi \left(\frac{d}{e} \right)^2$$

In practice d/e is in the order of 2 to 3, the ratio is then about 50.

Consequently:—

If the elastic ring is somewhat rigid there can be a resonance effect and, with the anti-vibrations handle held firmly, the longitudinal vibrations will be amplified and out of phase: the motion will be a series of figures of eight.

If the ring is normal the movement will be elliptical: the longitudinal vibration will be slightly transmitted to the handle and the transverse vibration hardly at all.

The treating element 2 of the devices of Figs. 1 and 2, which has been referred to as a brush, is in fact a brush-like element with a large number of soft, flexible filaments as bristles. The nature of this treating element forms a subsidiary feature of the invention. The bristles or filaments preferably have a length and rigidity such that their natural frequency of vibration is close to that of the vibration generator so that they enter into resonance with the vibration generator.

The graph of Fig. 3 represents the theoretical amplitude of resonance of a bristle in relation to its natural frequency of vibration for a driving frequency of 100 cycles per second at an amplitude of 2.3 mm. To get the largest possible amplitude at the tip of a dry bristle its weight and length are calculated so that its natural frequency is close to the driving frequency, when dry. Further, the maximum weight of paste a bristle can hold is 20 or 30 times its own weight. The useful portion of the resonance curve is thus

that between frequencies of $\frac{100}{5}$ per 100 or

120.

The practical graph is thus that shown in Fig. 4. The resonance amplitude can be reached when the bristle is dry and is equal to several times the driving amplitude. When the bristle is loaded with paste, the amplitude is smaller than the driving amplitude. It increases progressively along the AB curve, until the bristle is unloaded.

The cleaning capacity is a function of the acceleration transmitted from the brush to the paste on the teeth. The force exerted

depends upon this acceleration and the mass of a bristle plus the paste adhering to it.

The treating element can be made with bristles or cylindrical fibres, of a much smaller diameter than in any conventional brush. These are planted on a flexible textile surface, natural or artificial, set upon a rigid support. This support, like the handle of a brush, is set into the vibrator.

As an example, it is suggested that velvets should be used. The cutting of the threads leaves some very dense tufts of weft and warp. It is thus possible to have very short or very long bristle (up to 10 millimetres, or 0.4 inch, for example), dense and soft.

The ease of production, the thinness and density of the bristle, make velvet preferable from an industrial viewpoint. Moreover it is not possible by the usual methods to produce a brush plate with the desired quality of softness and elasticity, especially in the case of very short bristle to be used for the gums. Velvet, on the contrary, can easily be fixed on a very soft plate, without hardening it noticeably. The possibility of fixing velvet on any type of support enables the production of any shape of brush, fitted for industrial or hygienic purposes.

Another requirement is that the brush should be thin so as to avoid too much friction against the cheek. With velvet, the support can be made as thin as desired; otherwise, the thickness is a function of the length of implantation of the bristle.

As mentioned before, this invention is not limited to velvet. Other materials can have the same characteristics, such as:—

Spongy fabrics, where the threads form loops, each loop formed by two threads tied at the end.

Scraped fabrics, where the threads have been cut to form hair.

Jacquard fabrics and those of equivalent nature.

It is also possible to use a pad instead of a brush. It can be of a natural or artificial material, such as plastic, it can be spongy or not but it has to be flexible or soft. It can be cut in such a way that one face is extremely thin (1 or 2 millimetres, 0.04 to 0.08 inch) the other divided into very thin strips, thus forming bristle. Their diameter may vary from one end to the other.

The bristles just described have a frequency, length and rigidity such that their own frequency of vibration is close to the vibrator's. Each bristle moves noticeably on its support; it acts upon the tooth not only by its static rigidity, but also by the fast motion it transmits to the paste with $F = m\gamma$; m is the mass of the tip of the hair plus the tooth paste, and γ the acceleration given to this mass by the brush plus the kinetic energy of each hair when in contact with the tooth or the gum.

Let us consider, for example, two vibrating brushes, one with the relatively rigid bristle of a conventional brush, the other with the desired characteristic of thinness.

In the first case, the action of each bristle depends upon its flexion against the tooth or the gum (Fig. 5). It will be strong enough to injure the gums or damage the teeth, and not efficient enough to reach the space between the teeth because there is no flexion. If we use flexible bristles to preserve the teeth, then the cleaning efficiency is almost null.

On the contrary, according to the present invention, the cleaning efficiency depends mostly upon the kinetic energy of the active surface of the brush; this energy reaches its maximum when the bristle attains its position of static equilibrium.

It is then in the hollows and interstices of the teeth that the efficiency will be at its peak, and conversely the forces resulting from a flexion of the bristle are low, although sufficient to ensure a good cleaning of the surfaces without injury.

The cleaning action is also a function of the acceleration given by the brush to the paste: $F = m\ddot{a}$, where m is the mass of the active part of the brush (end of the hair) plus that of the adhering paste.

For the two reasons just described it is apparent that velvet, mohair or any similar fabric are quite superior: they can have a very thin and light support, a great density of hair and a light mass for each hair. Moreover it is very important that the fabric should adhere tightly to the handle. Although some similar fabrics have already been used in the place of bristles, this was not made a necessary requirement: they were then used to massage the gum, not to brush teeth. In a vibrating brush, the hair of the fabric acts really as a brush, and even more efficiently since they have a separate vibration frequency.

It is essential to stick the fabric tightly to the handle, either directly or on an intermediate support. This support should be rigid enough and easy to set on the handle (or on the axis transmitting the vibratory alternating motion), as shown in Fig. 6.

The length of the bristle must fulfil some other condition determined by the circumstances of utilisation on and between the teeth.

If the support for implantation of the bristle is set on a flat surface, a length sufficient to clean the intervals between the teeth is 5 millimetres (0.2 inch).

Another solution is to stick a shorter haired fabric on a curved surface. As an example Fig. 7 shows a partly spherical surface covered with velvet 6. The two end parts can reach inside the spaces, while the centre cleans the teeth. It is a great advan-

tage of this system to be adaptable to any shape of support.

We should note that the minimum and maximum bristle lengths vary from 2 to 12 millimetres (0.08 to 0.5 inch), while the range of amplitude for the motion of the support goes from 0.5 to 10 millimetres (0.02 to 0.4 inch). This amplitude is measured along the diameter or the maximum chord of the trajectory of one point on the active surface.

The frequency of the motion may vary from 10 cycles/sec. to 500 cycles/sec.

Various forms of electromagnetic vibration generator which may be employed in devices in accordance with the invention are shown in Figs. 8(a) and (b), 9(a) and (b), 10(a) and (b), and 11(a) and (b). In each of these vibration generators a laminated stator carries a coil 12 which is energised by current supplied by a cable 13. The coil 12 generates a magnetic flux through a rotor 14 which is indicated by the arrow 15 and as a result the rotor 14 rotates in bearings 17 and drives an eccentrically mounted weight 16.

In Figs. 8(a) and (b) the bearings 17 in which the shaft carrying the rotor 14 and the eccentric weight 16 is mounted are provided in the poles of the stator. In Figs. 9(a) and (b) the poles of the stator are separated by the diameter of the rotor and the bearings 17 are arranged one in the body of the stator and the other in a support 18 attached to the stator. In Figs. 10(a) and (b) a support 18 attached to the stator 11 provides one bearing 17 and the other is in one pole of the stator. In Figs. 11(a) and (b) the bearings 17 are arranged on either side of the stator 11 and the eccentric weight 16 is mounted outside one of the bearings.

To reduce the vibrating mass as much as possible the battery for supplying current to the motor may be placed in the non-vibrating handle and not in the watertight housing. The leads connecting the battery with the motor can pass into the housing through holes which are sealed to ensure water-tightness. In this case the motion would be almost circular.

Another possibility is to move the instrument by means of a compressed air turbine which either drives an eccentrically-mounted weight constituting a feeding head or itself acts as a feeding head. This system would not require as complete water-tightness as with electrical energy. It would also reduce considerably the weight of the housing and thus the vibrating mass.

It may be necessary that the system use very low energy so that any impact against the teeth or the gums would not be damaging. Friction of the tool against the cheek may cause some distortion of the circular motion since the inertia is then increased. It would be better to put a small shield

above the brush. The shield could be on the housing or on the handle.

Fig. 12 is an example of such a construction in which the housing 21 has two bearings 22, on which the axis 23 of a turbine 24 turns. An eccentric mass 25 is joined to the axis. The apparatus is connected to the source of power by a flexible tube set into a connecting pipe 26 in the housing 21. The compressed air coming through the pipe (in the direction of the arrow 27) makes the turbine 24 rotate and goes out through a port 28. The turbine drives the eccentric mass 25 which vibrates the apparatus in a plane parallel to the brush.

Other sources of energy can be used: mechanical energy for example.

In any case, if we use an electrical motor with a battery, we shall want the lowest possible consumption of energy (2 watts for example). The following characteristics are then necessary:—

Frequency: about and at least 50 cycles.

Amplitude of the motion of the support: about 2 millimetres, 0.08 inch.

The eccentric mass should be as close to the tool as possible, and the motor as far as possible.

With this construction the alternating motion of the tool would almost follow a straight line. Figs. 13(a) and (b) show such an example. A housing 31 holds a motor 32 to which a wire 33 supplies current. This motor 32 has a long shaft 34 with a bevel pinion 35 wedged at the end. The pinion 35 meshes with a pinion 36 which moves with a shaft 37 bearing the eccentric mass 38. This shaft spins between two bearings 39 set in the housing 31. The eccentric mass makes the brush 40 vibrate in a parallel plane along the arrow 41.

Definition of the best motion of the brush for better cleaning.

Referring to Fig. 14 we can see a tooth 42 set in the gum 43. In the interval 44 between the gum and the surface of the tooth the dental film and the food particles will infiltrate. One of the objectives of tooth cleaning is to take off these impurities.

A normal manual brushing is not efficient enough. We can see for example the motion of one bristle 2 as indicated by the arrow; it is the best possible but quite insufficient. This motion should be circular in a plane parallel to the tooth. We must remember that each point on the vibrating brush draws a circle of equal radius, none of the circles are concentric.

This motion is really the best, for if it were vertical it would just push the impurities below the gums. But let us study the effects of a circular motion. Fig. 15 is a cross section of the tooth 42. In the hand the brush moves as indicated by the arrow

46. If we consider the front and rear ends 47 and 48 of the tool, we can see that point 47 describes a circle. It picks up impurities on its way up and leaves them in the subgingival space. Then, for any other point 5 on the tool beneath 47 and 48 there will not be any impurity left on the tooth as it goes up and so each bristle will pick up the impurities and bring them down on the tooth 10 where they will be picked up again instantaneously by another bristle. They will be moved either towards the centre of the brush or down, but, in any case, the dental film will be broken and the impurities will be 15 washed away after rinsing of the mouth.

The same kind of reasoning applies to a brushing in the opposite direction or a brushing of the lower teeth.

The optimum amplitude of the motion 20 (diameter of the circle) is between 0.5 and 5 millimetres (0.02 to 0.2 inch). The best values range from 1.5 to 2.5 millimetres (0.06 to 0.1 inch). The amplitude does not really need to be greater than the length of 25 the subgingival space, otherwise there might be some impact against the gums or the ligaments. Here lies the net superiority of a circular motion, where each point of the tool moves along non-concentric circles. It 30 is by far preferable to a rotating motion of the tool (the rotation plane being still parallel to the teeth). In the latter case, the energy is transmitted by all the bristles together, and the whole inertia of the support is left 35 when the brush strikes against the gums, no matter how flexible the bristle might be. But in the vibratory motion each point on the tool is only elastically connected to the others so that it has a low kinetic or friction 40 energy, without possible harmful effect.

It is thus better for the brush to have circular vibratory movements, as defined above and this can be achieved with the device illustrated in Fig. 16. In this figure, 45 the arm 51 holding the treating element and joining it to the housing 52 is flexible in a direction perpendicular to the treating element, that is to the surface of the teeth. This flexibility will suppress any parasitic vibration 50 perpendicular to the tooth. The housing 52 contains a motor 53 and an eccentric mass 54 is mounted on the shaft of the motor 53.

Any other method of construction to obtain the same motion may also be used, such 55 as a transmission by means of axis and angle gearing to the feeding head. The motor can be taken off the housing if the feeding head is closed. A circular motion is obtained if both the centres of gravity of the housing and 60 of the tool are in one plane which includes the rotation plane of the feeding head.

Fig. 17 shows such a construction. A housing 55 carries a treating element 56 at one end. It has a socket 57 into which the 65 motor 58 is fitted by means of screws 59.

An eccentric mass 60 is fixed on the motor shaft and makes the tool vibrate in a plane parallel to the teeth.

The cleaning efficiency also depends in part of the shape of the treating element. 70

Figs. 18(a) and 18(b) show a brush 61 for cleaning the external surface of the teeth and the manner of its mounting in the housing 62. The brush 61 is interchangeable 75 with the angled brush shown in Figs. 19(a) and 19(b) which is designed for cleaning the internal surfaces of the teeth. Figs. 20(a) and (b), 21(a) and (b) and 22(a) and (b) show alternative forms of treating element.

Figs. 23 and 24 show a further device in accordance with the invention. An electric motor 63 is supported within a closed watertight housing 64 by a support 65 and an elastic ring 66 which centres the front of 80 the motor. A joint 67 ensures watertightness between the body of the housing 64 and a head 68. Self-lubricating bearings 69 in the head 68 support a shaft carrying an eccentrically mounted weight 70 and driven by the motor 63 through a coupling 71. 85

Current is fed to the motor 63 by a cable 72. A spring 73 forms one contact of a switch for setting the device in operation and can be pressed into contact with a fixed 90 contact 74 by a switch arm 75. 95

A brush 76 is carried by a support arm 77 which can be set in the head 68 in either of two positions corresponding to rotation of the arm 77 through 180°. The brush 76 can thus be used for cleaning both the internal and external faces of the teeth. 100

WHAT I CLAIM IS:—

1. A vibratory device for cleaning teeth and gums having a brush-like treating element with a large number of soft, flexible 105 filaments as bristles, a closed housing to which the treating element is attached, and a vibration generator so mounted within the housing that its vibrations are transmitted to the housing and hence to the treating element to cause the bristles to describe closed 110 non-concentric curves in a plane transverse to their length.

2. A device as claimed in Claim 1 in which the vibration generator is an electromagnetic vibrator incorporating an eccentrically mounted rotatable weight. 115

3. A device as claimed in Claim 1 in which the vibration generator consists of an electric motor arranged to rotate an eccentrically-mounted weight. 120

4. A device as claimed in Claim 3 in which the weight is rotated about the axis of rotation of the motor.

5. A device as claimed in Claim 2, 3 125 or 4 in which the electromagnetic vibrator or motor is fed from a battery mounted within the housing.

6. A device as claimed in Claim 2, 3, 4

- or 5 including a switch in the supply circuit to the electromagnetic vibrator or motor mounted inside the housing and operable through a flexible wall covering an aperture in the housing.
7. A device as claimed in Claim 1 in which the vibration generator is driven by an air turbine.
8. A device as claimed in Claim 7 in which the turbine forms or drives an eccentrically-mounted weight.
9. A device as claimed in any one of Claims 2 to 6 and 8 in which the treating element is attached to the housing by an arm extending in a direction generally transverse to the axis of rotation of the eccentric weight.
10. A device as claimed in Claim 9 in which the arm is flexible.
11. A device as claimed in Claim 9 or 10 in which the arm is reversible through an angle of 180° about its principal axis.
12. A device as claimed in any one of the preceding claims including an outer handle attached to the housing at the centre of vibration of the device.
13. A device as claimed in any one of the preceding claims in which the bristles of the treating element are supported by a flexible backing which is fixed to a rigid support.
14. A device as claimed in any one of the preceding claims in which the bristles of the treating element are formed by the pile of a piece of velvet material.
15. A device as claimed in any one of the preceding claims in which the bristles are of such length and rigidity that their natural frequency of vibration is close to that of the vibration generator.
16. A device as claimed in any one of the preceding claims in which the movement of the treating element is in a circle with an amplitude of between 0.5 and 5.0 mm.
17. A device as claimed in Claim 16 in which the amplitude is between 1.5 and 2.5 mm.
18. A vibratory device for cleaning teeth and gums in accordance with Claim 1 and substantially as described with reference to Figs. 23 and 24 of the accompanying drawings.

REDDIE & GROSE,
Agents for the Applicants.
6 Bream's Buildings, London, E.C.4.

Fig. 1.

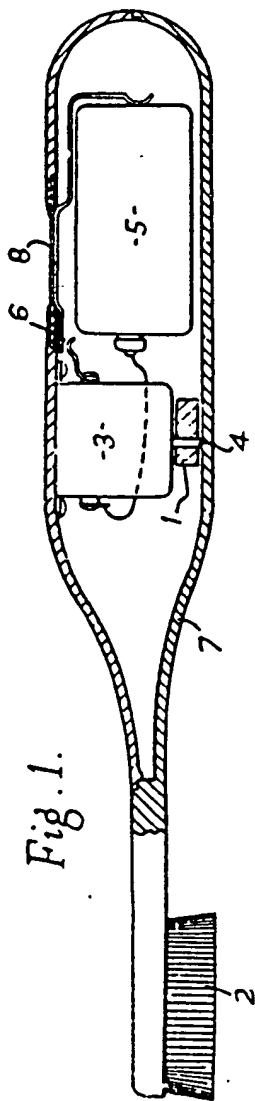


Fig. 3.

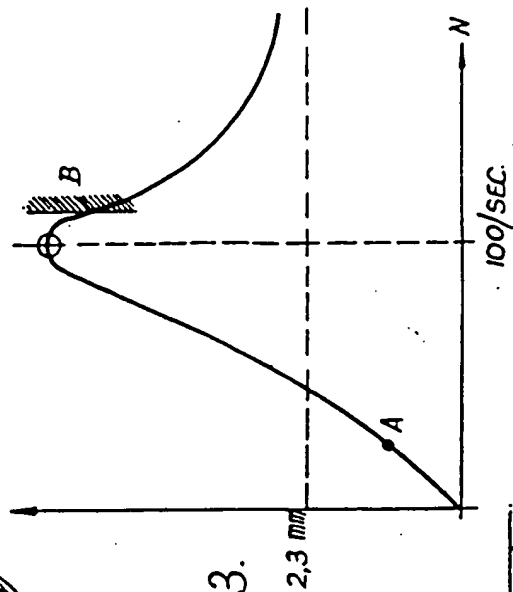


Fig. 2.

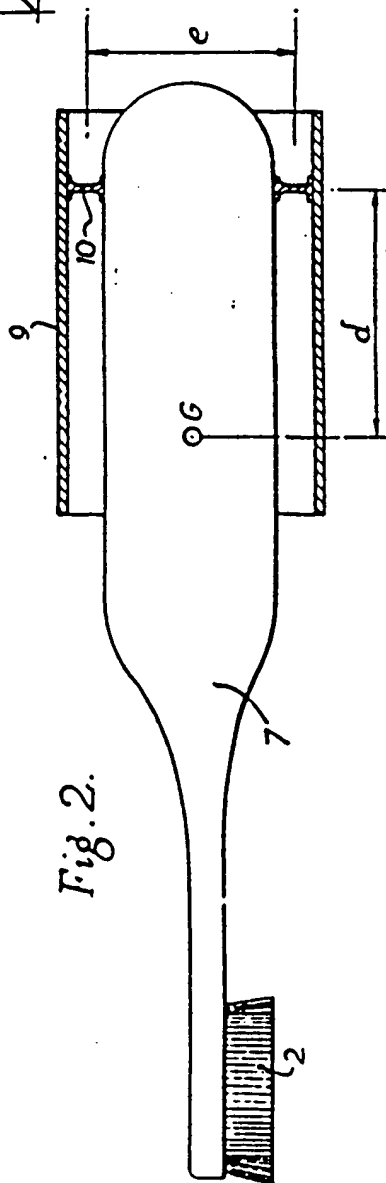


Fig. 5.

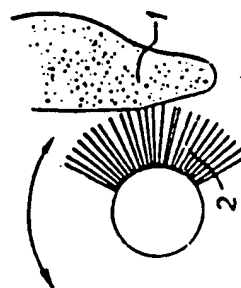


Fig. 6.

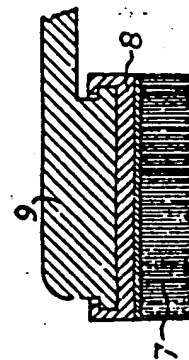


Fig. 7.



Fig. 4.

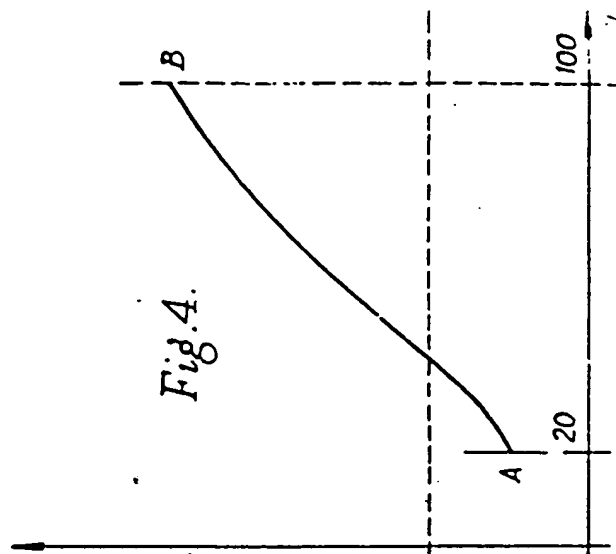


Fig. 8(a).

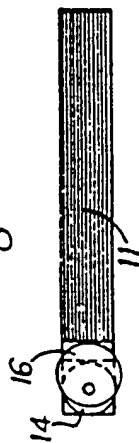


Fig. 8(b).

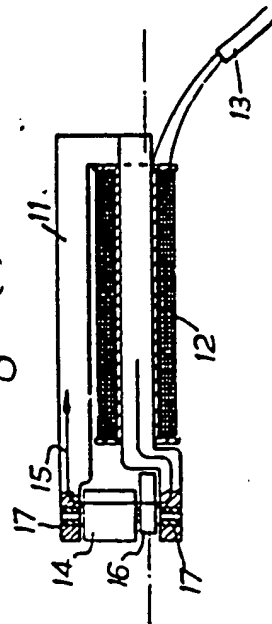


Fig. 9(a).

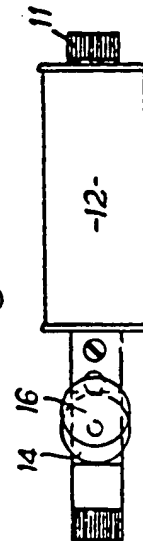


Fig. 9(b).

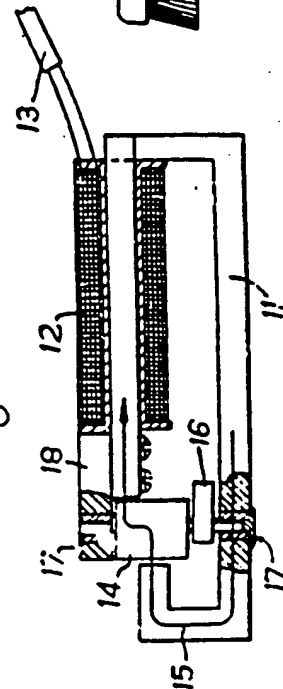


Fig. 10(b).

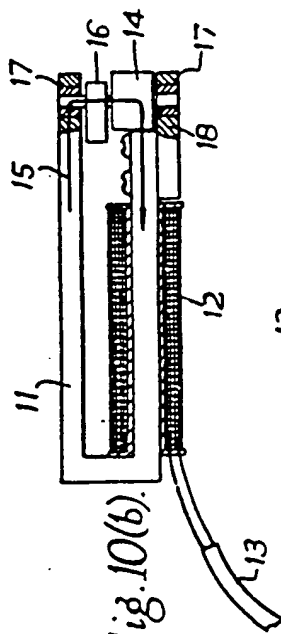


Fig. 10(a).

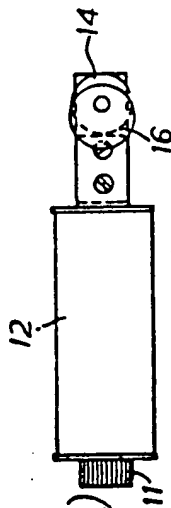


Fig. 11(a).

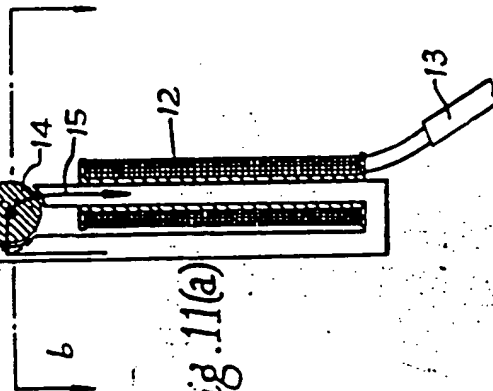


Fig. 11(b).

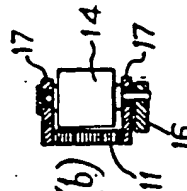


Fig. 12.

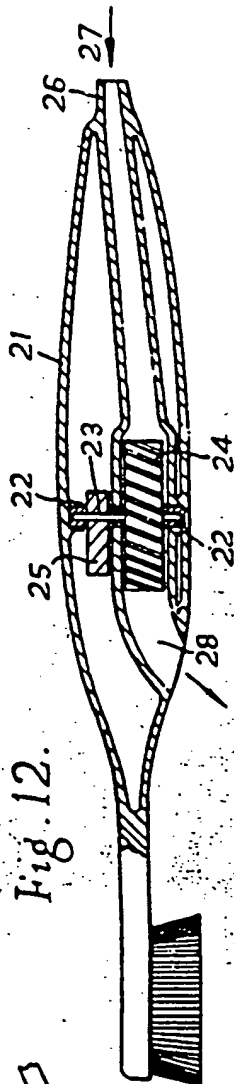


Fig. 13(a).

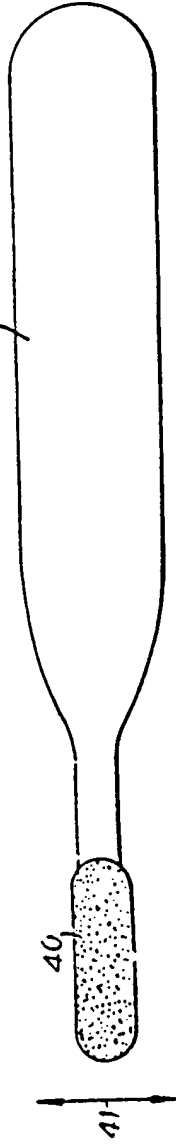


Fig. 13(b).

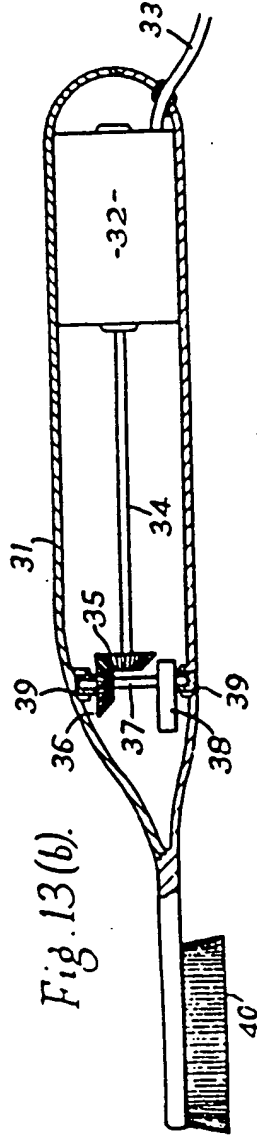


Fig. 16.

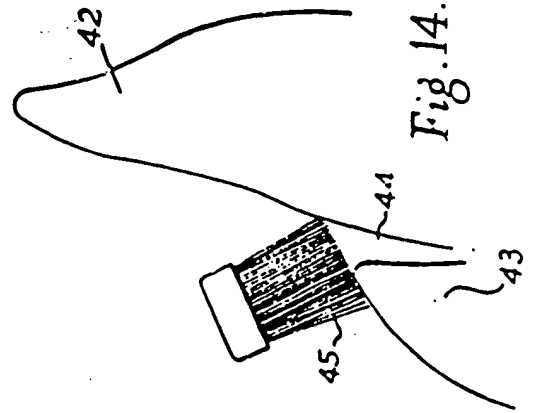
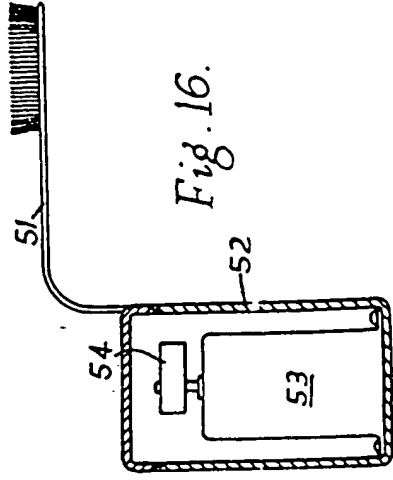


Fig. 14.

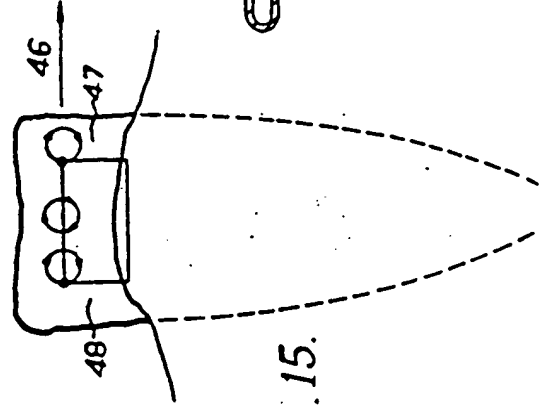
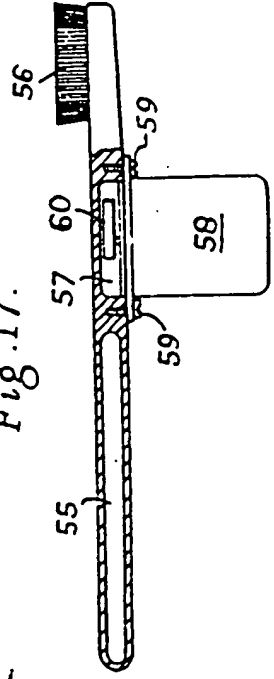
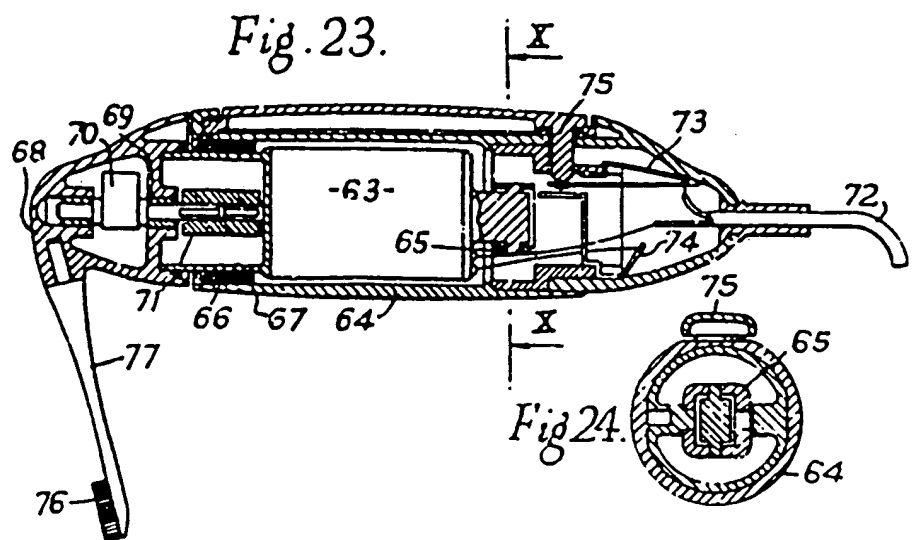
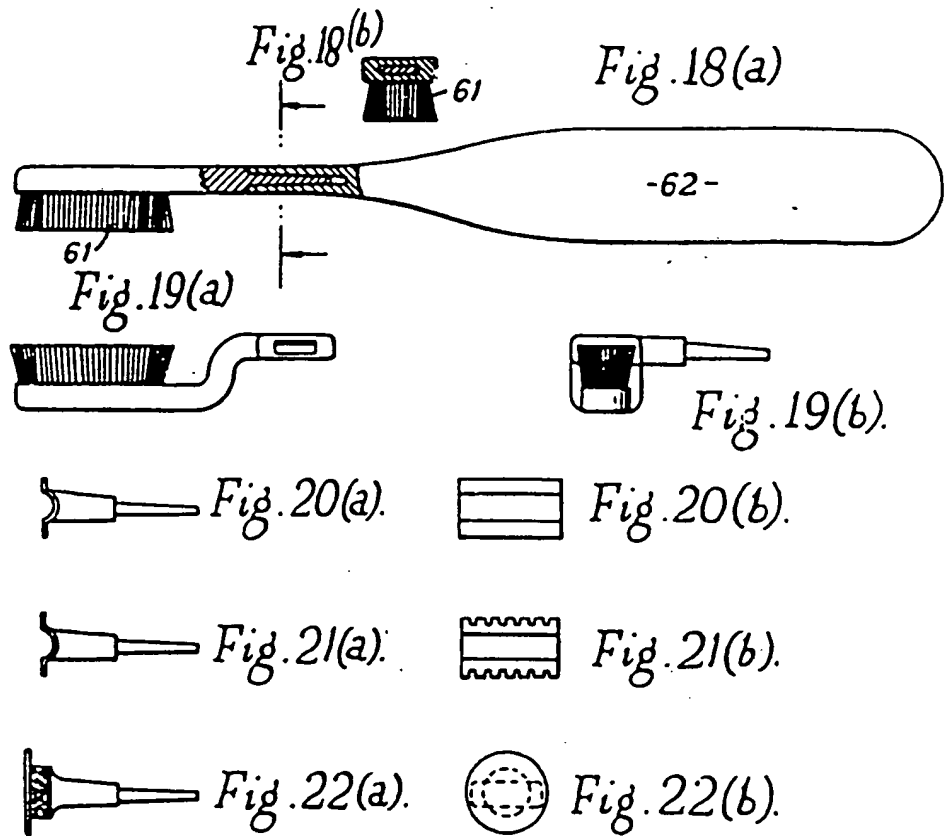


Fig. 15.

Fig. 17.





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